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(54) Mechanism for dividing tissue in a hemostat-style instrument

(57) Open electrosurgical forceps for sealing tissue are provided which include first and second shaft portions pivotably associated with one another. Each shaft portion has a jaw member disposed at a distal end thereof. Each of the jaw members includes an electrically conductive sealing surface adapted to communicate electrosurgical energy through tissue held therebetween and a slot formed through the sealing surface thereof. The forceps includes a cutting mechanism operatively associated with the first and second jaw members. The cutting mechanism includes a cutting element disposed within the slot of the at least one jaw member, the cutting element being movable from a first position wherein the cutting element is retracted within the at least one jaw member and a second position in which the cutting element at least partially projects from a sealing surface of the at least one jaw member.

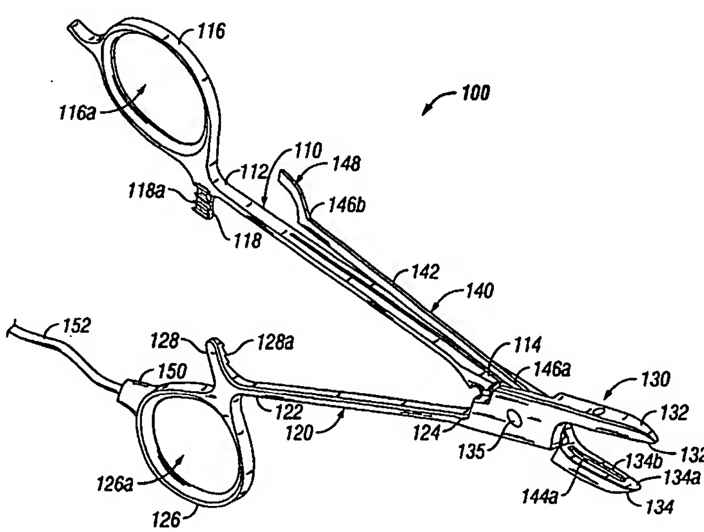

FIG. 1A

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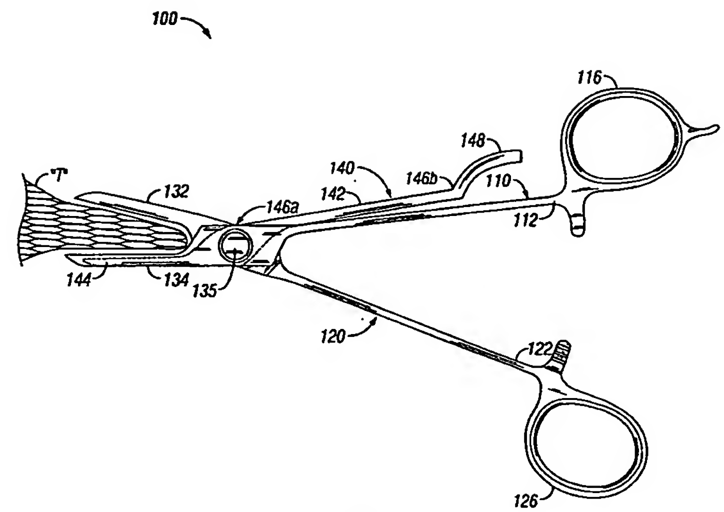


FIG: 1B

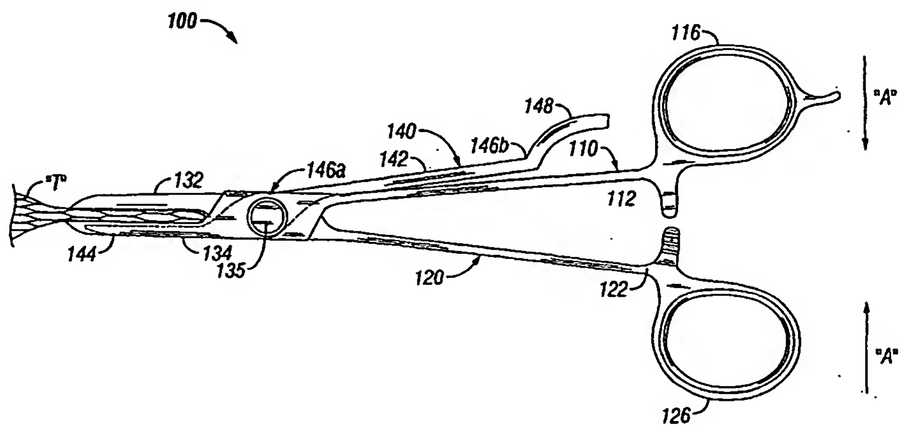


FIG. 1C

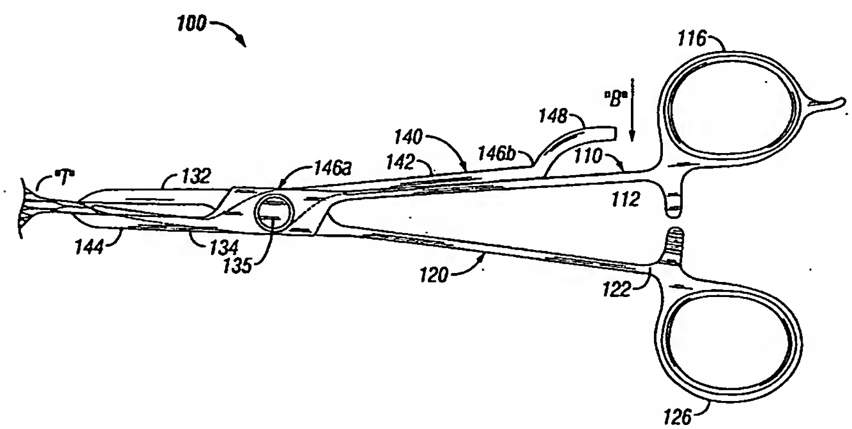


FIG. 1B

Description

CROSS REFERENCE TO RELATED APPLICATION:

[0001] This application claims the benefit of priority to U.S. Provisional Application Serial No. 60/616,968 filed on October 8, 2004 entitled "MECHANISM FOR DIVIDING TISSUE IN A HEMOSTAT-STYLE INSTRUMENT" the entire contents of which being incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates to forceps used for open surgical procedures. More particularly, the present disclosure relates to an open forceps which applies a combination of mechanical clamping pressure and electrosurgical energy to seal tissue and a cutting device which is selectively activatable to sever tissue.

Technical Filed

[0003] A forceps is a plier-like instrument which relies on mechanical action between its jaws to grasp, clamp and constrict vessels or tissue therebetween. So-called "open forceps" are commonly used in open surgical procedures whereas "endoscopic forceps" or "laparoscopic forceps" are, as the name implies, used for less invasive endoscopic surgical procedures. Electrosurgical forceps (open or endoscopic) utilize both mechanical clamping action and electrical energy to effect hemostasis by heating tissue and blood vessels to coagulate and/or cauterize tissue.

[0004] Certain surgical procedures require more than simply cauterizing tissue and rely on the unique combination of clamping pressure, precisely controlling the application of electrosurgical energy and the gap distance (i.e., distance between opposing jaw members or opposing conducting surfaces when closed about tissue) to "seal" tissue, vessels and certain vascular bundles.

[0005] Vessel sealing or tissue sealing is a recently-developed technology which utilizes a unique combination of radiofrequency energy, pressure and gap control to effectively seal or fuse tissue between two opposing jaw members or sealing plates. Vessel or tissue sealing is more than "cauterization" which is defined as the use of heat to destroy tissue (also called "diathermy" or "electrodiathermy") and vessel sealing is more than "coagulation" which is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. "Vessel sealing" is defined as the process of liquefying the collagen, elastin and ground substances in the tissue so that it reforms into a fused mass with significantly-reduced demarcation between the opposing tissue structures.

[0006] In order to effectively "seal" tissue or vessels, two predominant mechanical parameters must be accurately controlled: 1) the pressure applied to the vessel or tissue; and 2) the gap distance between the conductive tissue contacting surfaces (electrodes). As can be appreciated, both of these parameters are affected by the thickness of the tissue being sealed. Accurate application of pressure is important for several reasons: to reduce the tissue impedance to a low enough value that allows enough electrosurgical energy through the tissue; to overcome the forces of expansion during tissue heating; and to contribute to the end tissue thickness which is an indication of a good seal. It has been determined that a good seal for certain tissues is optimum between 0.001 inches and 0.006 inches.

[0007] With respect to smaller vessels or tissue, the pressure applied becomes less relevant and the gap distance between the electrically conductive surfaces becomes more significant for effective sealing. In other words, the chances of the two electrically conductive surfaces touching during activation increases as the tissue thickness and the vessels become smaller.

[0008] Commonly owned, U.S. Patent No. 6,511,480, PCT Patent Application Nos. PCT/US01/11420 and PCT/US01/11218, U.S. Patent Applications Serial Nos. 10/116,824, 10/284,562 and 10/299,650 all describe various open surgical forceps which seal tissue and vessels. All of these references are hereby incorporated by reference herein. In addition, several journal articles have disclosed methods for sealing small blood vessels using electrosurgery. An article entitled Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator, J. Neurosurg., Volume 75, July 1991, describes a bipolar coagulator which is used to seal small blood vessels. The article states that it is not possible to safely coagulate arteries with a diameter larger than 2 to 2.5 mm. A second article is entitled Automatically Controlled Bipolar Electrocoagulation - "COA-COMP", Neurosurg. Rev. (1984), pp. 187-190, describes a method for terminating electrosurgical power to the vessel so that charring of the vessel walls can be avoided.

[0009] Typically and particularly with respect to open electrosurgical procedures, once a vessel is sealed, the surgeon has to remove the sealing instrument from the operative site, substitute a new instrument and accurately sever the vessel along the newly formed tissue seal. As can be appreciated, this additional step may be both time consuming (particularly when sealing a significant number of vessels) and may contribute to imprecise separation of the tissue along the sealing line due to the misalignment or misplacement of the severing instrument along the center of the tissue sealing line.

[0010] Many endoscopic vessel sealing instruments have been designed which incorporate a knife or blade member which effectively severs the tissue after forming a tissue seal. For example, commonly-owned U.S. Application Serial Nos. 10/116,944; 10/179,863; and 10/460,926 all describe endoscopic instruments which effectively seals and cuts tissue along the tissue seal. Other instruments include blade members or shearing members which simply cut tissue in a mechanical and/or electromechanical manner and are relatively ineffective

for vessel sealing purposes.

[0011] There exists a need to develop an open electrosurgical forceps which is simple, reliable and inexpensive to manufacture and which effectively seals tissue and vessels and which allows a surgeon to utilize the same instrument to effectively sever the tissue along the newly formed tissue seal.

SUMMARY

[0012] Forceps for use in open surgical procedures are provided. According to one aspect of the present disclosure, an open electrosurgical forceps for sealing tissue is provided. The forceps includes first and second shaft portions pivotably associated with one another. Each shaft portion has a jaw member disposed at a distal end thereof. The jaw members are movable from a first position in spaced relation relative to one another to at least one subsequent position wherein the jaw members cooperate to grasp tissue therebetween. Each of the jaw members includes an electrically conductive sealing surface for communicating electrosurgical energy through tissue held therebetween. At least one of the jaw members includes a slot formed through the sealing surface thereof.

[0013] The forceps further includes a cutting mechanism operatively associated with the first and second jaw members. The cutting mechanism includes a cutting element disposed within the slot of the at least one jaw member. The cutting element is movable from a first position wherein the cutting element is retracted within the slot of the at least one jaw member and a second position in which the cutting element at least partially projects from the sealing surface of the at least one jaw member. The cutting mechanism further includes an actuator operatively associated with the cutting element which upon movement thereof selectively advances the cutting element from the first position to the second positions.

[0014] In one embodiment, the actuator is integrally associated with the cutting element. The cutting mechanism is pivotable about a pivot which connects the first and second jaw members. The actuator is spaced a distance from the first shaft portion. The actuator selectively activates the cutting element when moved relative to the first shaft portion.

[0015] In another embodiment, the cutting mechanism may include a drive rod extending through a channel formed in at least one of the first and second shaft portions. The drive rod includes a distal end operatively connected to the cutting element. The cutting mechanism may further include a tab operatively connected to the drive rod for manipulating the drive rod to urge the cutting element between the first and second positions.

[0016] The cutting element is supported in the slot of the jaw member such that proximal displacement of the drive rod urges the cutting element from within the slot of the jaw member to cut tissue. Desirably, the cutting element includes at least one angled slot defined therethrough which receives a pivot pin fixed to one of the jaw members.

[0017] In one embodiment, each angled slot formed in the cutting element includes a first portion in close proximity to the sealing surface and a second portion extending distally and away from the sealing surface. Proximal movement of the drive rod urges the cutting element from the first position to the second position by a camming action between the pin and the slot formed in the cutting element.

[0018] The open electrosurgical forceps may further include a biasing element for urging the drive rod to a distal-most position. The cutting element is pivotably disposed within the slot of the jaw member. The cutting element projects out through the jaw member and defines a camming surface.

[0019] In one embodiment, the second shaft portion reciprocably supports the actuator. The actuator is movable from a first position spaced from the cutting element to a second position in contact with the cutting element. In use, displacement of the actuator from the first position to the second position, the actuator engages the camming surface of the cutting element and urges the cutting element from the first position to the second position.

[0020] The open electrosurgical forceps may further include a biasing element for urging the cutting element to the first position. It is envisioned that movement of the actuator pivots the cutting element between the first and second positions.

[0021] According to another aspect of the present disclosure, the open electrosurgical forceps may include a pair of shaft portions pivotably coupled to one another at a pivot point. Each shaft portion includes a jaw member at a distal end thereof for grasping tissue therebetween. Each jaw member includes a sealing surface for conducting electrosurgical energy through tissue grasped therebetween and one of the sealing surfaces has a slot formed therein. The forceps further includes a cutting mechanism operatively coupled to the shaft portions and has a cutting element operatively secured proximate the distal end of the forceps. The cutting mechanism is selectively movable from a first position in which the cutting element is retracted within the slot and a second position in which the cutting element at least partially projects from the slot to cut tissue disposed between the jaw members.

[0022] In one embodiment, the cutting mechanism includes a drive rod extending through a channel formed in at least one of the first and second shaft portions. The drive rod includes a distal end operatively connected to the cutting element. The cutting mechanism further includes a tab operatively connected to the drive rod for manipulating the drive rod to urge the cutting element between the first and second positions.

[0023] The cutting element is operatively engaged in the slot of the one jaw member such that axial displacement of the drive rod results in transverse displacement of the cutting element from the slot to cut tissue disposed

between jaw members.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Various embodiments of the present disclosure are described with reference to the following drawing figures. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

[0025] FIG. 1A is a perspective view of a forceps according to one embodiment of the present disclosure;

[0026] FIG. 1B is a side, elevational view of the forceps of FIG. 1A shown in an open position;

[0027] FIG. 1C is a side, elevational view of the forceps of FIGS. 1A and 1 B shown in a closed position and the cutting assembly shown in an unactuated position;

[0028] FIG. 1 D is a side, elevational view of the forceps of FIGS. 1A-1C shown in a closed position and the cutting assembly shown in an actuated position;

[0029] FIG. 2A is a cross-sectional, side elevational view of an alternate embodiment of a forceps according to the present disclosure;

[0030] FIG. 2B is an enlarged view of the indicated area of detail of FIG. 2A, illustrating a cutting element of the forceps in a first position;

[0031] FIG. 2C is an enlarged view of the indicated area of detail of FIG. 2A, illustrating the cutting element of the forceps in a second position;

[0032] FIG. 2D is an enlarged view of the indicated area of detail of FIG. 2A, illustrating a cutting element of the forceps according to an alternate embodiment of the disclosure;

[0033] FIG. 3A is an enlarged, schematic side elevational view of a distal end of a forceps constructed according to another embodiment of the present disclosure, illustrating a cutting assembly in a first position;

[0034] FIG. 3B is an enlarged, schematic side elevational view of the distal end of the forceps of FIG. 3A, illustrating the cutting assembly in a second position;

[0035] FIG. 3C is an enlarged, schematic view of an alternate biasing arrangement for the cutting assembly shown in a first position;

[0036] FIG. 3D is an enlarged, schematic view of an alternate biasing arrangement of FIG. 3C in a second position;

[0037] FIG. 4A is an enlarged schematic side elevational view of a distal end of a forceps constructed according to yet another embodiment of the present disclosure, illustrating a cutting assembly in a first position; and

[0038] FIG. 4B is an enlarged schematic side elevational view of the distal end of the forceps of FIG. 4A, illustrating the cutting assembly in a second position.

DETAILED DESCRIPTION

[0039] Referring now to FIGS. 1A-1D, a forceps or hemostat for use in open surgical procedures is generally designated as 100. Forceps 100 includes a first elongated shaft portion 110 and a second elongated shaft portion 120 each having a proximal end 112 and 122, respectively. In the drawings and in the descriptions which follow, the term "proximal", as is traditional, will refer to the end of forceps 100 which is closer to the user, while the term "distal" will refer to the end which is further from the user.

[0040] Forceps 100 includes an end effector assembly 130 which attaches to distal ends 114, 124 of shaft portions 110, 120, respectively. As explained in more detail below, end effector assembly 130 includes a pair of opposing jaw members 132, 134 which are pivotably connected about a pivot pin 135 and which are movable relative to one another to grasp tissue therebetween.

[0041] Each shaft portion 110 and 120 includes a handle 116, 126, respectively, disposed at proximal ends 112, 122, thereof. Each handle 116, 126 defines a finger hole 116a, 126a, respectively, therethrough for receiving a finger of the user. As can be appreciated, finger holes 116a, 126a, facilitate movement of shaft portions 110 and 120 relative to one another which, in turn, pivot the jaw members 132 and 134, about pivot pin 135, from an open position wherein the jaw members 132 and 134 are disposed in spaced relation relative to one another to a clamping or closed position wherein jaw members 132 and 134 cooperate to grasp tissue therebetween.

[0042] Shaft portions 110, 120 are designed to transmit a particular desired force to the opposing sealing surfaces 132a, 134a of jaw members 132, 134, respectively, when clamped. In particular, since shaft portions 110, 120 effectively act together in a spring-like manner (i.e., bending that behaves like a spring), the length, width, height and deflection of shaft portions 110, 120 will directly effect the overall transmitted force imposed on opposing jaw members 132, 134. Jaw members 132, 134 are more rigid than shaft portions 110, 120 and the strain energy stored in the shaft portions 110, 120 provides a constant closure force between jaw members 132, 134.

[0043] Each shaft portion 110, 120 also includes a ratchet portion 118, 128. Each ratchet, e.g., 118, extends from a proximal end of its respective shaft portion 110 towards the other ratchet 128 in a generally vertically aligned manner. The inner facing surfaces of each ratchet 118, 128 includes a plurality of flanges 118a, 128a, respectively, which project from the inner facing surface of each ratchet 118, 128 such that the ratchets 118, 128 can interlock in at least one position. In the embodiment shown in FIG. 1A, ratchets 118, 128 interlock at several different positions. Each ratchet position holds a specific, i.e., constant, strain energy in shaft portions 110, 120 which, in turn, transmits a specific force to jaw members 132, 134.

[0044] One of the shaft portions, e.g., shaft portion 120, includes a proximal shaft connector 150 which is designed to connect forceps 100 to a source of electrosurgical energy, e.g., an electrosurgical generator (not shown). Connector 150 electromechanically engages a conducting cable 152 such that the user may selectively

apply electrosurgical energy as needed.

[0045] As briefly discussed above, jaw members 132, 134 are selectively movable about pivot pin 135 from the open position to the closed position for grasping tissue therebetween. Jaw members 132 and 134 are generally symmetrical and include similar component features which cooperate to permit facile rotation about pivot pin 135 to effect the grasping and sealing of tissue. As a result and unless otherwise noted, jaw member 132 and the operative features associated therewith are initially described herein in detail and the similar component features with respect to jaw member 134 will be briefly summarized thereafter. Moreover, many of the features of jaw members 132 and 134 are described in detail in commonly-owned U.S. Patent Application Serial Nos. 10/284,562, 10/116,824, 09/425,696, 09/178,027 and PCT Application Serial No. PCT/US01/11420 the contents of which are all hereby incorporated by reference in their entirety herein.

[0046] Jaw member 132 includes an electrically conductive sealing surface 132a which conducts electrosurgical energy of a first potential to the tissue upon activation of forceps 100. Exemplary embodiments of conductive sealing surface 132a are discussed in commonly-owned, co-pending PCT Application Serial No. PCT/US01/11412 and commonly owned, co-pending PCT Application Serial No. PCT/US01/11411, the contents of both of these applications being incorporated by reference herein in their entirety.

[0047] Similar to jaw member 132, jaw member 134 includes an electrically conductive sealing surface 134a for conducting electrosurgical energy of a second potential to the tissue upon activation of forceps 100.

[0048] It is envisioned that one of the jaw members, e.g., 132, includes at least one stop member (not shown) disposed on the inner facing surface of the electrically conductive sealing surface 132a (and/or 134a). Alternatively or in addition, the stop member(s) may be positioned adjacent to the electrically conductive sealing surfaces 132a, 134a or proximate the pivot pin 135. The stop member(s) is/are designed to define a gap between opposing jaw members 132 and 134 during sealing. The separation distance during sealing or the gap distance is within the range of about 0.001 inches (~0.03 millimeters) to about 0.006 inches (~0.016 millimeters).

[0049] A detailed discussion of these and other envisioned stop members as well as various manufacturing and assembling processes for attaching, disposing, depositing and/or affixing the stop members to the electrically conductive sealing surfaces 132a, 134a are described in commonly-assigned, co-pending PCT Application Serial No. PCT/US01/11222 and U.S. Application Serial No. 10/471,818 which are both hereby incorporated by reference in their entirety herein.

[0050] As mentioned above, two mechanical factors play an important role in determining the resulting thickness of the sealed tissue and effectiveness of the seal, i.e., the pressure applied between opposing jaw members 132 and 134 and the size of the gap between opposing jaw members 132 and 134 (or opposing sealing surface 132a and 134a during activation). It is known that the thickness of the resulting tissue seal cannot be adequately controlled by force alone. In other words, too much force and jaw members 132 and 134 may touch and possibly short resulting in little energy traveling through the tissue thus resulting in an inadequate seal. Too little force and the seal would be too thick. Applying the correct force is also important for other reasons: to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough current through the tissue; and to overcome the forces of expansion during tissue heating in addition to contributing towards creating the required end tissue thickness which is an indication of a good seal.

[0051] Sealing surfaces 132a and 134a are relatively flat to avoid current concentrations at sharp edges and to avoid arcing between high points. In addition, and due to the reaction force of the tissue when engaged, jaw members 132 and 134 are manufactured to resist bending, i.e., tapered along their length to provide a constant pressure for a constant tissue thickness at parallel and the thicker proximal portion of jaw members 132 and 134 will resist bending due to the reaction force of the tissue.

[0052] As best shown in FIGS. 1A-1D, forceps 100 further includes a cutting mechanism 140 operatively associated therewith. Cutting mechanism 140 includes an arm portion 142 pivotably connected to one of the first and second shaft portions 110, 120, a cutting element 144 (e.g., blade, knife, scalpel, etc.) disposed at a distal end 146a thereof, and a finger gripping element 148 disposed at a proximal end 146b thereof.

[0053] Cutting mechanism 140 is pivotably coupled to shaft portion 110 about pivot pin 135. Cutting mechanism 140 is pivotably coupled to shaft portion 110 in such a manner that cutting element 144 is biased (via a spring or the like) in a retracted position within a slot 134b defined in sealing surface 134a of jaw member 134. Cutting mechanism 140 is selectively movable about pivot pin 135 to deploy cutting element 144 from within slot 134b to cut tissue. Cutting element 144 may also be movably retractable depending upon a particular purpose.

[0054] In particular, cutting mechanism 140 is pivotable from a first position in which cutting element 144 is retained at least substantially within slot 134b of jaw member 134 to a second position in which cutting element 144 is deployed from jaw member 134. When cutting element 144 is disposed in jaw member 134, arm portion 142 of cutting assembly 142 is spaced a distance from shaft portion 110.

[0055] With reference to FIGS. 1B-1D, a method of using forceps 100 will now be described in detail. As seen in FIG. 1 B, with shaft portions 110, 120 in the open position, such that jaw members 132, 134 are spaced from one another, and with cutting assembly 140 in the first position (i.e., within slot 134b), jaw members 132, 134 are maneuvered around the target tissue "T". As seen in

FIG. 1C, following manipulation and positioning of jaw members 132, 134 about target tissue "T", forceps 100 is moved from the open position to the closed position. In particular, proximal ends 112, 122 of shaft portions 110 and 120 are moved toward one another, in the direction of arrows "A", to thereby proximate jaw members 132, 134 toward one another.

[0056] In so doing, target tissue "T" is clamped or grasped between jaw members 132, 134. Desirably, the user then activates a hand switch or a foot switch (not shown) to provide electrosurgical energy to each jaw member 132, 134 to communicate energy through target tissue "T" held therebetween to effect a tissue seal. Once target tissue "T" is sealed, as seen in FIG. 1 D, cutting mechanism 140 is actuated, e.g., arm portion 142 is moved toward shaft portion 110 in the direction of arrow "B", to sever target tissue "T" along the tissue seal. In particular, upon movement of arm portion 142 cutting element 144 pivots about pivot pin 135 and deploys from jaw member 134 toward jaw member 132 to thereby slice, cut and/or otherwise divide target tissue "T" along the previously formed tissue seal.

[0057] Turing now to FIGS. 2A-2C, a forceps in accordance with another embodiment of the present disclosure is shown generally as 200. Forceps 200 is similar to forceps 100 and will only be described in detail to the extent necessary to identify differences in construction and operation.

[0058] Forceps 200 includes a cutting mechanism 240 operatively associated therewith. Cutting mechanism 240 includes a drive rod 242 for advancing cutting mechanism 240 through shaft portion 210, which will be explained in greater detail below. Drive rod 242 includes a distal end 242a configured to mechanically support a cutting element 244. Cutting element 244 is disposed in slot 234b formed in seal surface 234a of jaw member 234 (see FIG. 2B). Cutting mechanism 240 further includes a finger tab 246 operatively associated with drive rod 242 such that movement of finger tab 246 moves drive rod 242 in the corresponding direction.

[0059] Shaft portion 210 includes at least one guide channel 222 formed therein for controlling and/or guiding drive rod 242 through movement therethrough. Drive rod 242 is made from a flexible wire or plastic sheath which does not buckle upon movement thereof.

[0060] A spring 248 may be employed within guide channel 222 to bias cutting mechanism 240 back to the unactuated position upon proximal movement of tab 246 such that upon release of finger tab 246, the force of spring 248 automatically returns cutting mechanism 240 to its distal-most position within guide channel 222 which, in turn, retracts cutting element 244 within slot 234. While a spring 248 is shown for maintaining cutting mechanism 240 in a distal-most position, it is envisioned and within the scope of the present disclosure that a spring, e.g., a coil spring, (not shown) can be operatively associated therewith for maintaining cutting mechanism 240 in a proximal-most position and wherein finger tab 246 is positioned so as to drive cutting mechanism 240 in a distal direction.

[0061] As best seen in FIGS. 2B and 2C, cutting element 244 is provided with at least one elongated slot, preferably a pair of elongated slots 244a, 244b, formed therein. Slots 244a, 244b are oriented at an angle with respect to the longitudinal axis of forceps 200. The portion of slots 244a, 244b which is closest to seal surface 234a of jaw member 234 is located proximal of the portion of slots 244a, 244b which is furthest from seal surface 234a of jaw member 234.

[0062] A pin 250 is provided within each slot 244a, 244b. Each pin 250 is fixedly positioned relative to jaw member 234. When cutting element 244 is in a distal-most position, pins 250 are located in the portion of slots 244a, 244b closest to seal surface 234a.

[0063] As seen in FIGS. 2B and 2C, in operation and following application of electrosurgical energy to jaw members 232, 234, to thereby seal the target tissue held therebetween, the user activates finger tab 246 to thereby urge drive rod 242 in a proximal direction, as indicated by arrow "A". In so doing, cutting element 244 is urged in an angular direction relative to the longitudinal axis, as indicated by arrows "B". In particular, cutting element 244 is drawn both proximally and toward jaw member 232 (i.e., deployed from slot 234b formed in sealing surface 234a of jaw member 234, to thereby slice the target tissue which is clamped between jaw members 232, 234. In other words, cutting element 244 is drawn in direction "B" by the camming action created between slots 244a, 244b and pins 250. While cam slots 244a, 244b may be diagonal, as seen in FIG. 2D, cutting element 244 may be provided with cam slots 244a' and 244b' having a diagonal portion and a longitudinally extending portion integrally connected to the diagonal portion to thereby by create a slicing or cutting motion for cutting element 244.

[0064] Following the cutting of the target tissue, finger tab 246 may be released to thereby allow the force of spring 248 to automatically return cutting mechanism 240 to its distal-most position within guide channel 222 for subsequent sealing and cutting, which, as mentioned above, retract cutting element 244 to within slot 234b.

[0065] Turing now to FIGS. 3A-3D, a forceps 300, having a distal end in accordance with another embodiment of the present disclosure, is shown. Forceps 300 is similar to forceps 100 and 200 and will only be described in detail to the extent necessary to identify differences in construction and operation.

[0066] Forceps 300 includes a cutting mechanism 340 operatively associated therewith. Cutting mechanism 340 includes a cutting element 344 disposed in slot 334b formed in sealing surface 334a of jaw member 334. Cutting element 344 includes a camming surface 346 at a rear portion thereof, i.e., which extends outwardly from a side opposite sealing surface 334a of jaw member 334.

[0067] Cutting element 344 is pivotably supported in slot 334b by a pivot pin 350. A biasing member 348, e.g.,

a torsion spring or the like, may be employed within jaw member 334 to bias cutting element 344 in a retracted, i.e., undeployed, condition. Upon at least partial deployment of cutting element 344, biasing member 348 is biased such that upon release of cutting element 344, the force of the biasing member 348 automatically returns cutting element 344 into jaw member 334. Cutting mechanism 340 further includes an advancing sheath 342 operatively associated with forceps 300 for deploying cutting element 344. Any type of known actuation may be employed to advance sheath 342.

[0068] As seen in FIGS. 3A and 3B, following application of electrosurgical energy to jaw members 132, 134 to seal tissue held therebetween, the user advances sheath 342 a distal direction, as indicated by arrow "A", to engage camming surface 346 of cutting element 344 and urge cutting element 344 out of slot 334b in the direction of arrow "B" to sever tissue. Following the cutting of the tissue, sheath 342 is withdrawn in a proximal direction until camming surface 346 of cutting element 344 is disengaged. The force of biasing member 348 automatically returns cutting mechanism 340 into slot 334b of jaw member 334.

[0069] Turning now to FIGS. 3C and 3D, a detailed discussion of biasing member 348 is provided. As seen in FIG. 3C, cutting element 344 includes a rear flange or arm 360 which defines a notch 362 formed between a proximal end of cutting element 344 and arm 360. Notch 362 is located proximal of pin 350. Notch 362 extends through cutting edge 347 of cutting element 344. Cutting element 344 is fabricated from spring type steel or any other material exhibiting resilient characteristics.

[0070] In operation, as seen in FIGS. 3C and 3D, as cutting element 344 is urged out of slot 334b of jaw member 334, in the direction of arrow "B" (FIG. 3B), notch 362 closes against the bias created by arm 360. Following the cutting of the target tissue, sheath 342 is withdrawn in a proximal direction until camming surface 346 of cutting element 344 is disengaged. The biasing force created by arm 360 automatically returns cutting mechanism 340 into slot 334b of jaw member 334.

[0071] Turning now to FIGS. 4A and 4B an alternative embodiment includes a cutting element 444 is pivotably connected to a drive rod 452 by a pin 454. In this manner, as drive rod 452 is driven in a distal direction, as indicated by arrow "A", cutting element 444 is pivoted about pin 450 and urged out of slot 334b of jaw member 334. Following the cutting step, drive rod 452 is withdrawn in a proximal direction to urge cutting element 444 back into jaw member 334.

[0072] It is envisioned and within the scope of the present disclosure that a biasing member, e.g., a spring, (not shown) may be provided for returning cutting element 444 into jaw member 334 following deployment by drive rod 452.

[0073] It is further envisioned and within the scope of the present disclosure to provide a cutting element 444 configured such that cutting element 444 is pivotable about pivot pin 435.

[0074] It is envisioned that any of the cutting elements disclosed herein may be fabricated from plastic and/or metal (e.g., stainless steel, titanium, etc.). Desirably, the cutting elements are fabricated from non-conductive materials to thereby reduce the potential for stray currents and/or shorting.

[0075] From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the same. For example, none of the aforedescribed forceps require that the tissue be necessarily cut after sealing or that the tissue be sealed prior to cutting. As can be appreciated, this gives the user additional flexibility when using the instrument.

[0076] For example, it is also contemplated that forceps 100, 200 and/or 300 (and/or the electrosurgical generator used in connection therewith) may include a sensor or feedback mechanism (not shown) which automatically selects the appropriate amount of electrosurgical energy to effectively seal the particularly-sized tissue grasped between the jaw members. The sensor or feedback mechanism may also measure the impedance across the tissue during sealing and provide an indicator (visual and/or audible) that an effective seal has been created between jaw members 132 and 134. Commonly-owned U.S. Patent Application No. 10/073,761, filed on February 11, 2002, entitled "Vessel Sealing System"; U.S. Patent Application No. 10/626,390, filed on July 24, 2003, entitled "Vessel Sealing System"; U.S. Patent Application No. 10/427,832, filed on May 1, 2003, entitled "Method and System for Controlling Output of RF Medical Generator"; U.S. Patent Application No. 10/761,524, filed on January 21, 2004, entitled "Vessel Sealing System"; U.S. Provisional Application No. 60/539,804, filed on January 27, 2004, entitled "Method of Tissue Fusion of Soft Tissue by Controlling ES Output Along Optimal Impedance Curve"; U.S. Provisional Application No. 60/466,954; filed on May 1, 2003, entitled "Method and System for Programming and Controlling an Electrosurgical Generator System"; and U.S. Patent No. 6,398,779, disclose several different types of sensory feedback mechanisms and algorithms which may be utilized for this purpose. The contents of these applications are hereby incorporated by reference herein.

[0077] Experimental results suggest that the magnitude of pressure exerted on the tissue by the sealing surfaces of jaw members 132 and 134 are important in assuring a proper surgical outcome. Tissue pressures within a working range of about 3 kg/cm^2 to about 16 kg/cm^2 and, desirably, within a working range of 7 kg/cm^2 to 13 kg/cm^2 have been shown to be effective for sealing arteries and vascular bundles. Tissue pressures within the range of about 4 kg/cm^2 to about 6.5 kg/cm^2 have proven to be particularly effective in sealing arteries and particular tissue bundles.

[0078] While several embodiments of the disclosure

have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

Claims

1. An open electrosurgical forceps for sealing tissue, comprising:

    first and second shaft portions pivotably associated with one another, each shaft portion having a jaw member disposed at a distal end thereof, the jaw members being movable from a first position in spaced relation relative to one another to at least one subsequent position wherein the jaw members cooperate to grasp tissue therebetween, each of the jaw members including an electrically conductive sealing surface being configured to communicate electrosurgical energy through tissue held therebetween, at least one of the jaw members including a slot formed through the sealing surface thereof;
    a cutting mechanism operatively associated with the first and second jaw members, the cutting mechanism including:

        a cutting element disposed within the slot of the at least one jaw member, the cutting element being movable from a first position wherein the cutting element is retracted within the at least one jaw member and a second position in which the cutting element at least partially projects from a sealing surface of the at least one jaw member; and
        an actuator operatively associated with the cutting element which upon movement thereof selectively advances the cutting element from the first position to the second positions.

2. The open electrosurgical forceps according to claim 1, wherein the actuator is integrally associated with the cutting element.

3. The open electrosurgical forceps according to claim 1 or 2, wherein the cutting mechanism is pivotable about a pivot which connects the first and second jaw members.

4. The open electrosurgical forceps according to any one of the preceding claims, wherein the actuator is spaced a distance from the first shaft portion.

5. The open electrosurgical forceps according to any one of the preceding claims, wherein the actuator selectively activates the cutting element when moved relative to the first shaft portion.

6. The open electrosurgical forceps according to any one of the preceding claims, wherein the cutting mechanism includes;
    a drive rod extending through a channel formed in at least one of the first and second shaft portions, the drive rod including a distal end operatively connected to the cutting element; and
    a tab operatively connected to the drive rod which manipulates the drive rod to urge the cutting element between the first and second positions.

7. The open electrosurgical forceps according to claim 6, wherein the cutting element is supported in the slot of the jaw member such that proximal displacement of the drive rod urges the cutting element from within the slot of the jaw member to cut tissue.

8. The open electrosurgical forceps according to any one of the preceding claims, wherein the cutting element includes at least one angled slot defined therethrough which receives a pivot pin fixed to one of said jaw members.

9. The open electrosurgical forceps according to claim 8, wherein each angled slot formed in the cutting element includes a first portion in close proximity to the sealing surface and a second portion extending distally and away from the sealing surface.

10. The open electrosurgical forceps according to claim 9, wherein proximal movement of the drive rod urges the cutting element from the first position to the second position by a camming action between the pin and the slot formed in the cutting element.

11. The open electrosurgical forceps according to any one of claims 6 to 10, further comprising a biasing element for urging the drive rod to a distal-most position.

12. The open electrosurgical forceps according to any one of the preceding claims, wherein the cutting element is pivotably disposed within the slot of the jaw member.

13. The open electrosurgical forceps according to claim 12, wherein the cutting element extends out through the jaw member and defines a camming surface.

14. The open electrosurgical forceps according to claim 13, wherein the second shaft portion reciprocably

supports the actuator, the actuator being movable from a first position spaced from the cutting element to a second position in contact with the cutting element.

15. The open electrosurgical forceps according to claim 14, wherein upon displacement of the actuator from the first position to the second position, the actuator engages the camming surface of the cutting element and urges the cutting element from the first position to the second position.

16. The open electrosurgical forceps according to any one of the preceding claims, further comprising a biasing element configured to urge the cutting element to the first position.

17. The open electrosurgical forceps according to any one of the preceding claims, wherein movement of the actuator pivots the cutting element between the first and second positions.

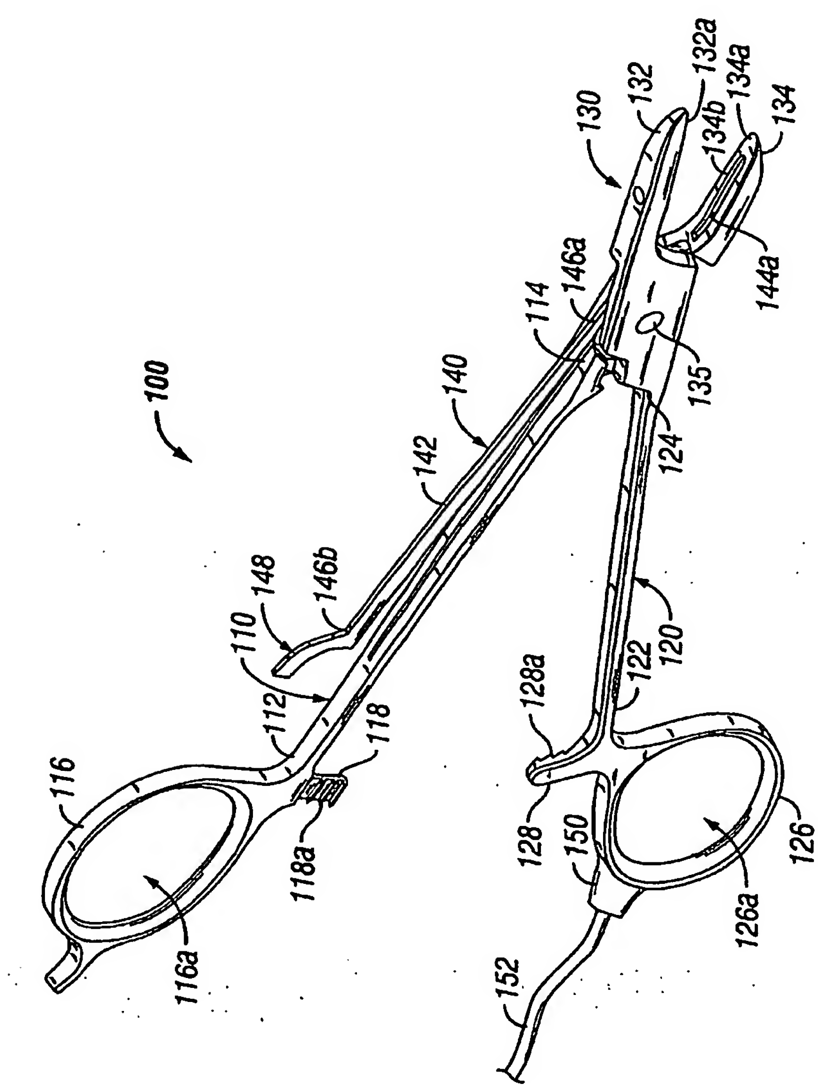
18. An open electrosurgical forceps for sealing tissue, comprising:

a pair of shaft portions pivotably coupled to one another at a pivot point, each shaft portion including a jaw member at a distal end thereof for grasping tissue therebetween, each jaw member including a sealing surface adapted to conduct electrosurgical energy through tissue grasped therebetween and one of the sealing surfaces includes a slot defined therein;
a cutting mechanism operatively coupled to the shaft portions having a cutting element operatively secured proximate the distal end of the forceps, the cutting mechanism being selectively moveable from a first position in which the cutting element is retracted within the slot and a second position in which the cutting element at least partially projects from the slot to cut tissue disposed between the jaw members.

19. The open electrosurgical forceps according to claim 18 wherein the cutting mechanism includes:

a drive rod extending through a channel formed in at least one of the first and second shaft portions, the drive rod including a distal end operatively connected to the cutting element; and
a tab operatively connected to the drive rod which manipulates the drive rod to urge the cutting element between the first and second positions.

20. The open electrosurgical forceps according to claim 19 wherein the cutting element is operatively engaged in the slot of the one jaw member such that axial displacement of the drive rod results in transverse displacement of the cutting element from the slot to cut tissue disposed between the jaw members.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134b
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144a
146a
146b
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152

FIG. 1A

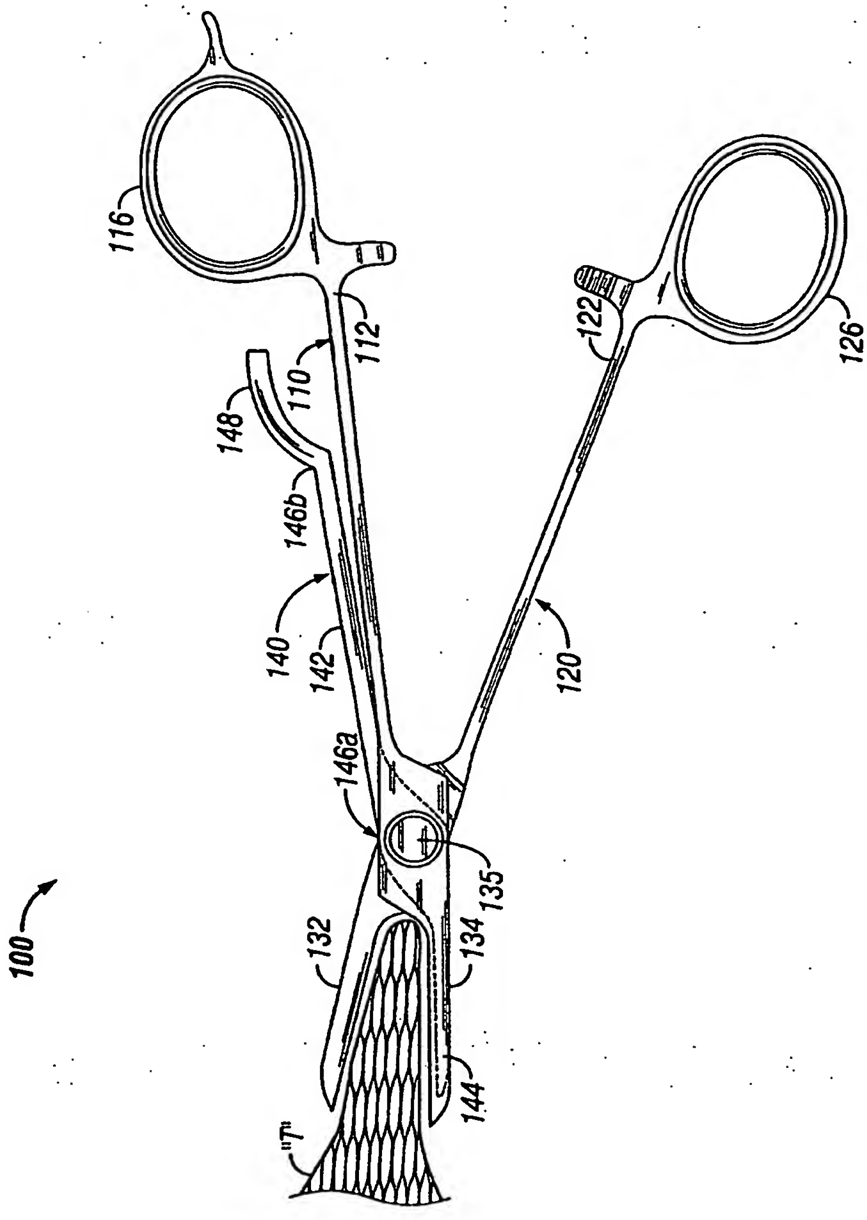
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FIG. 1B

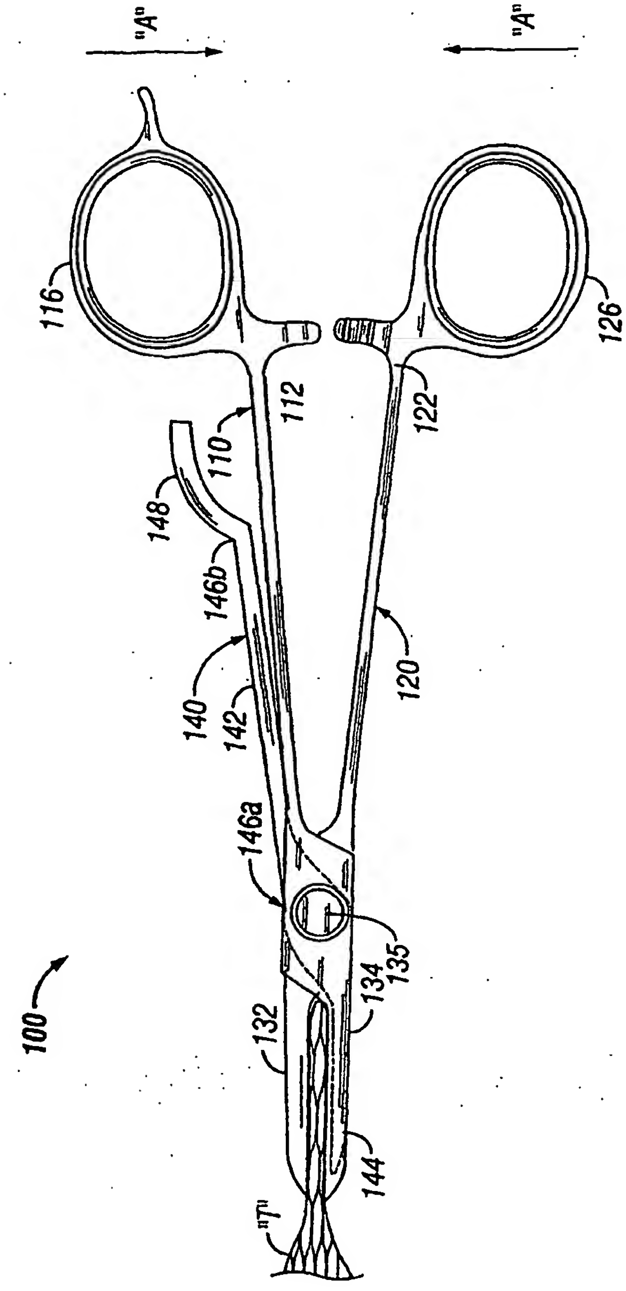
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FIG. 1C

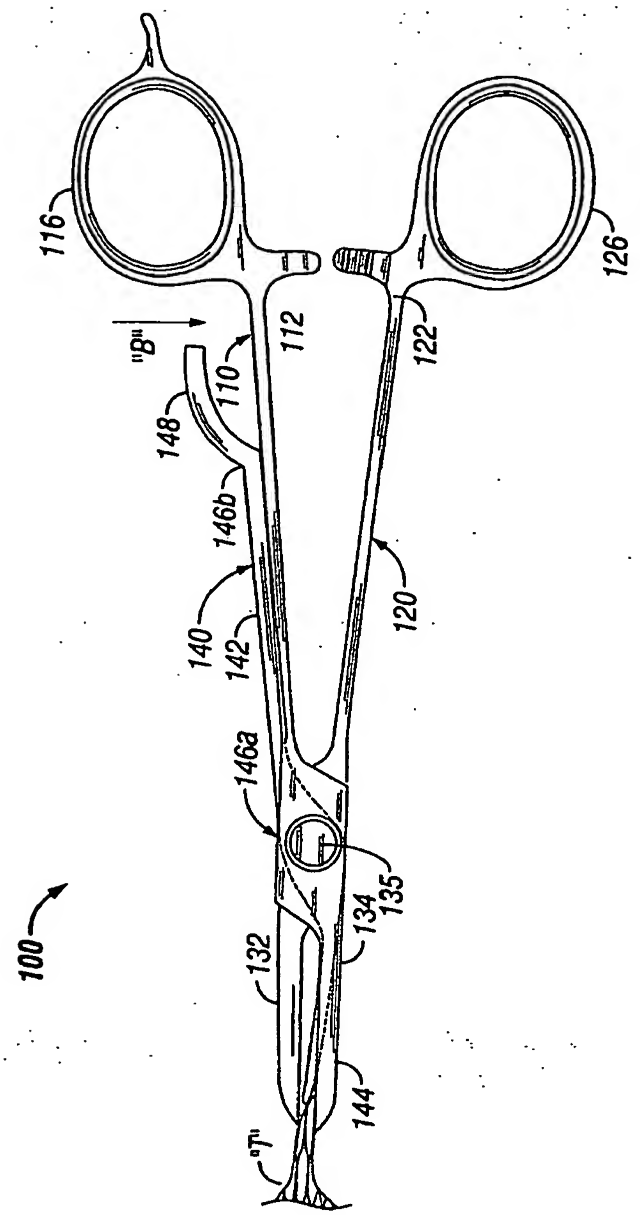
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FIG. 1B

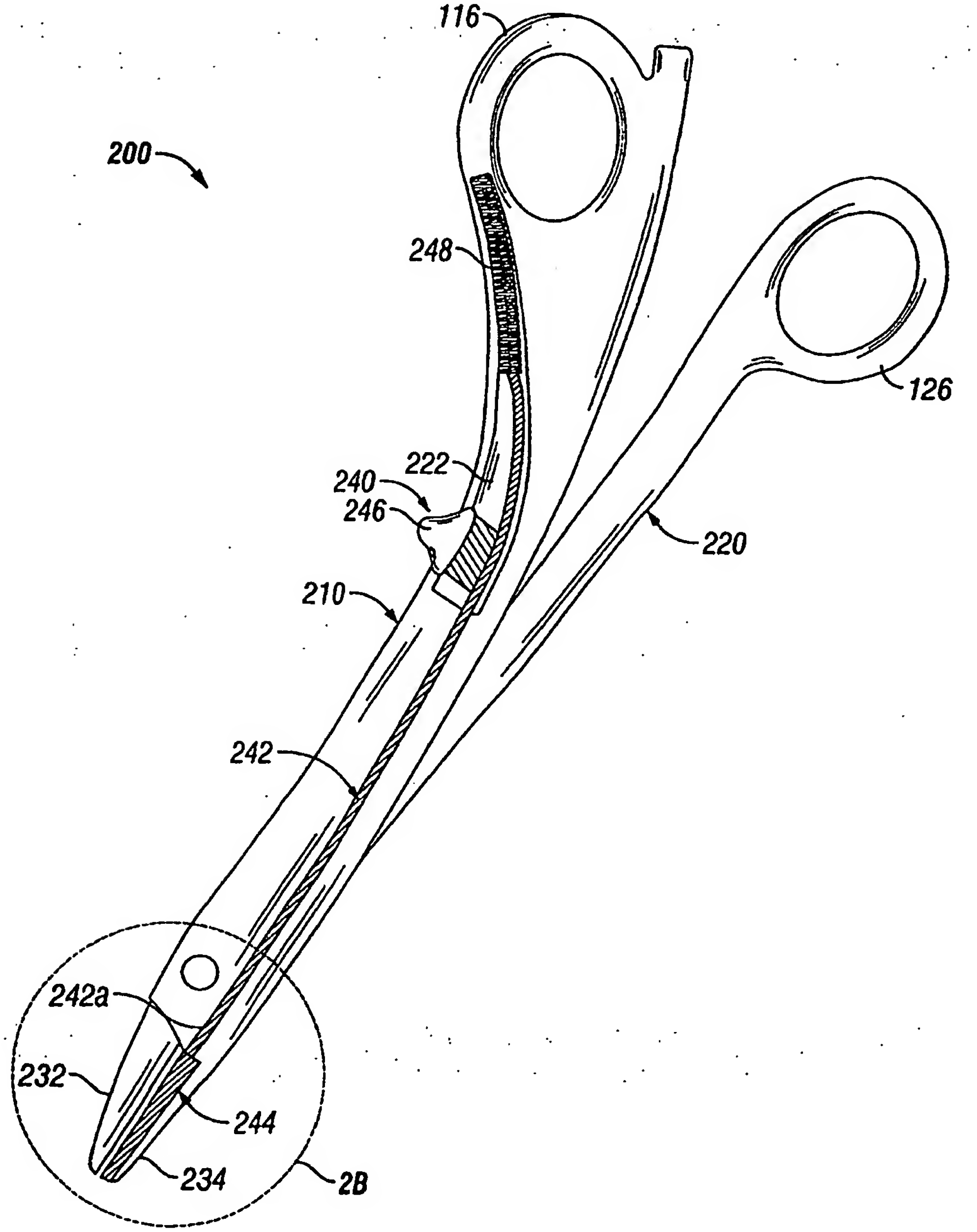

FIG. 2A

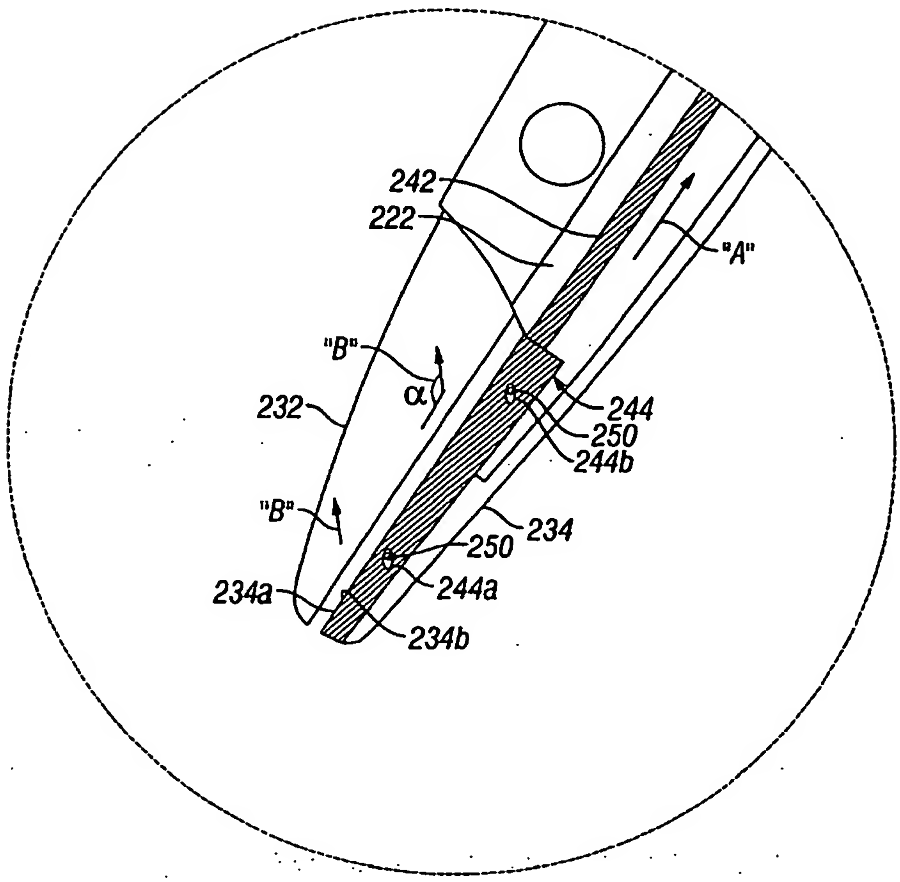

FIG. 2B

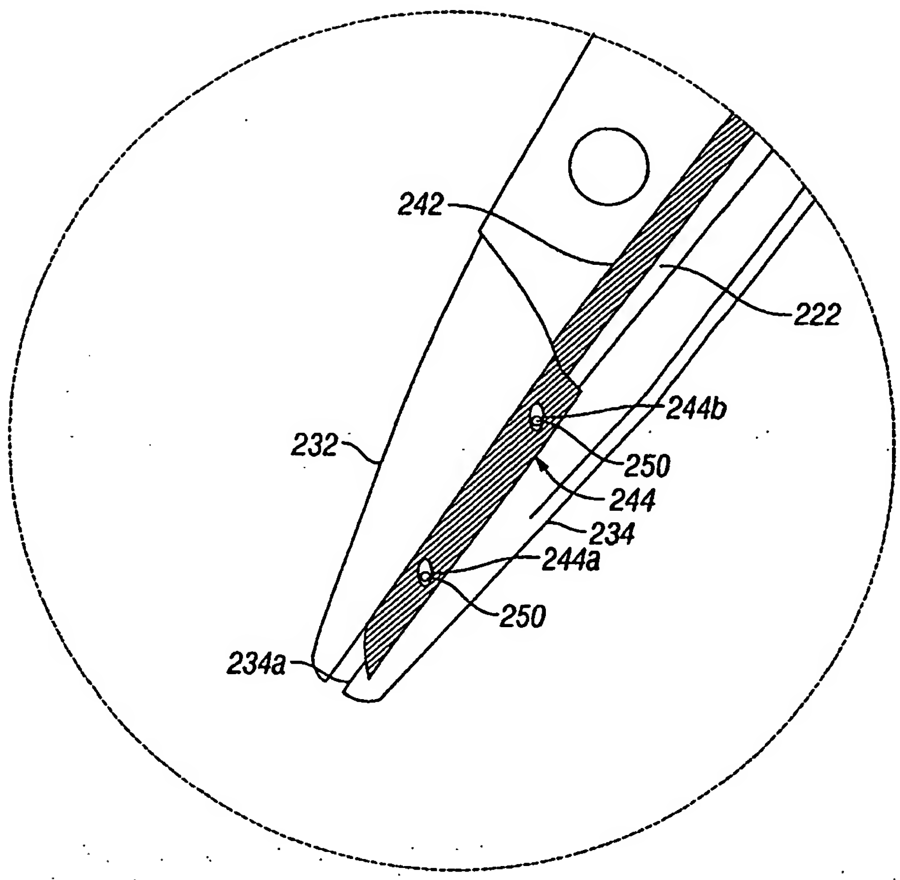

FIG. 2C

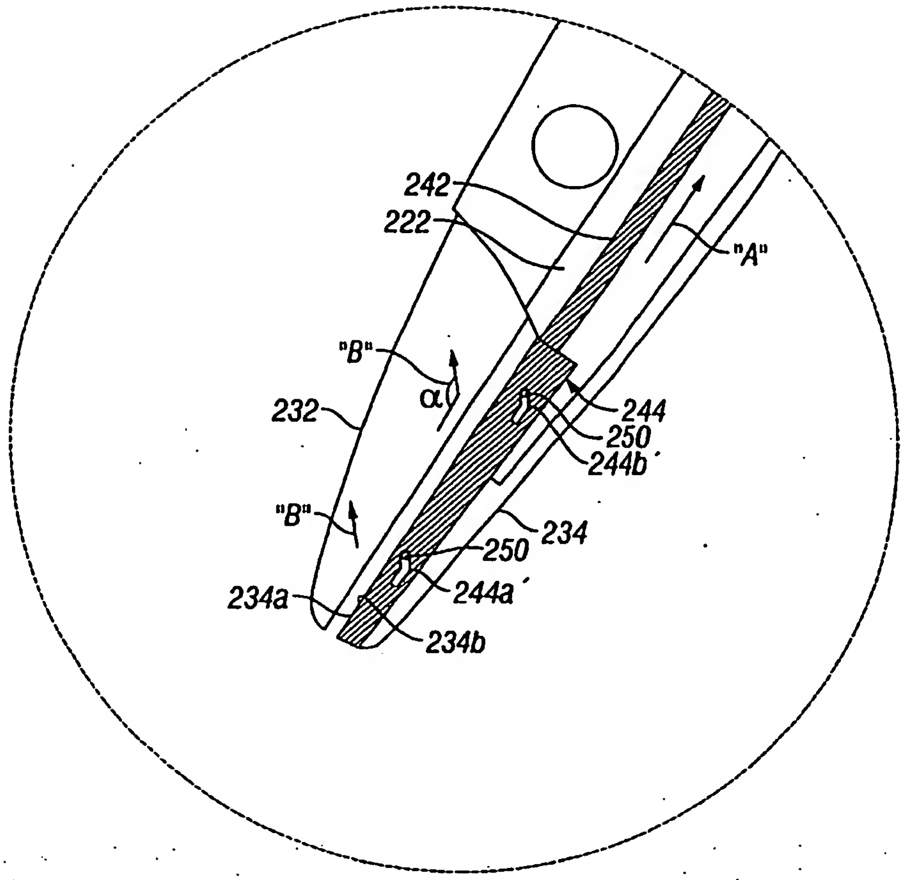

FIG. 2D

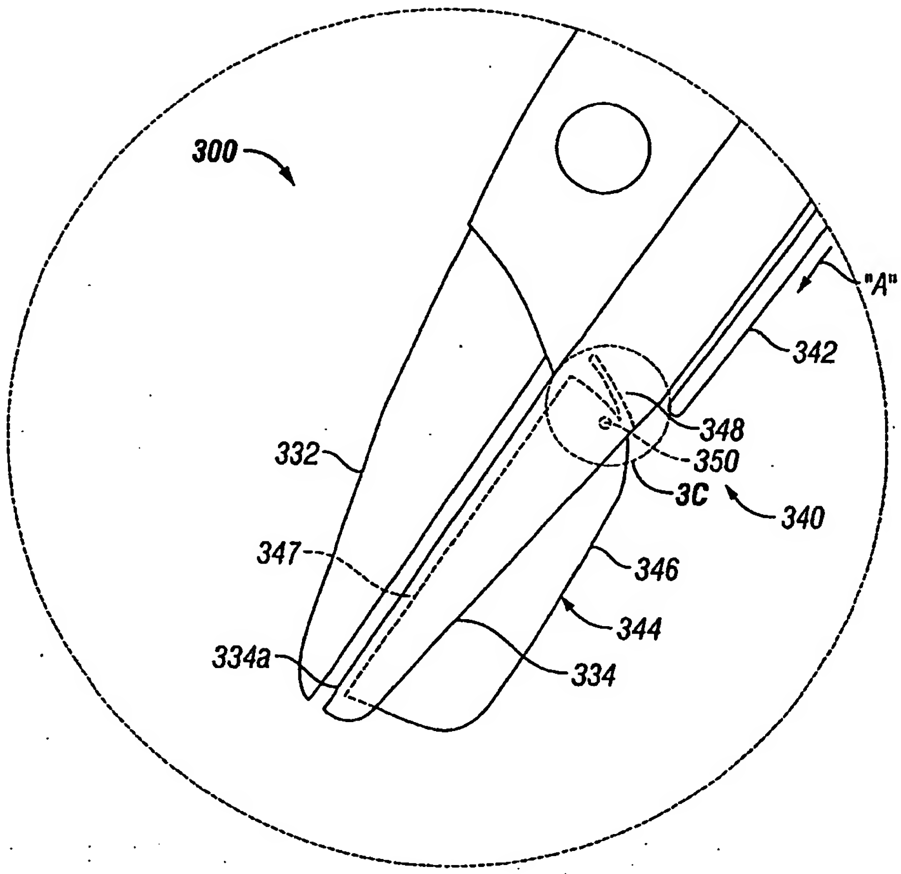

FIG. 3A

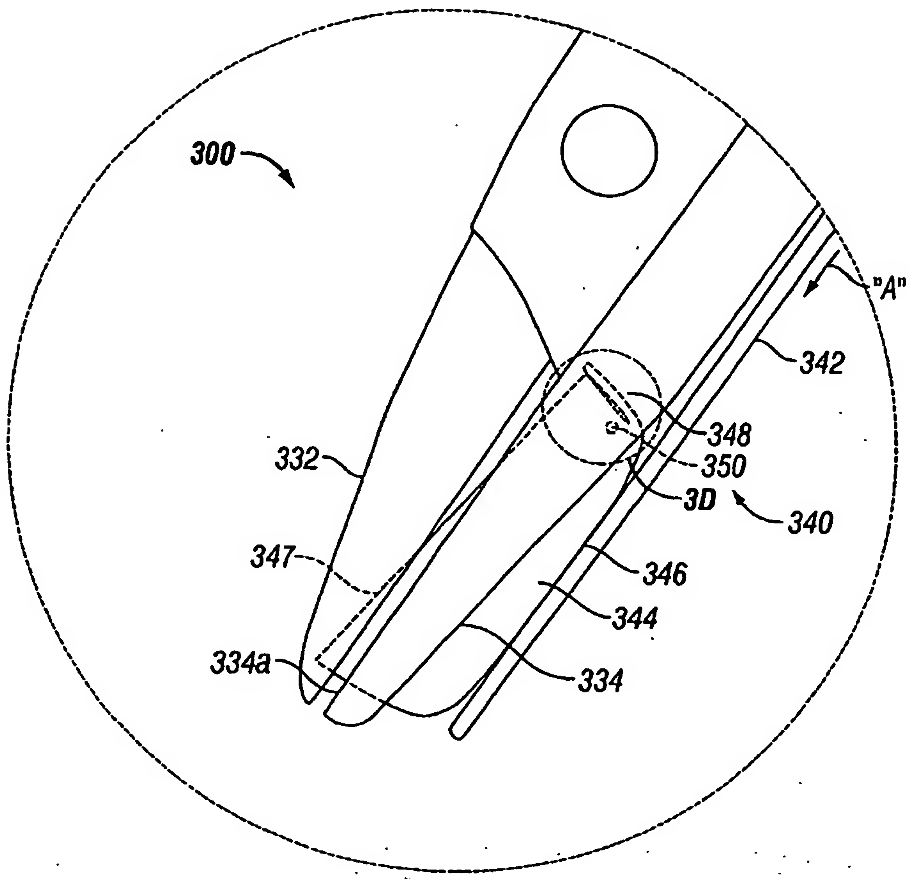

FIG. 3B

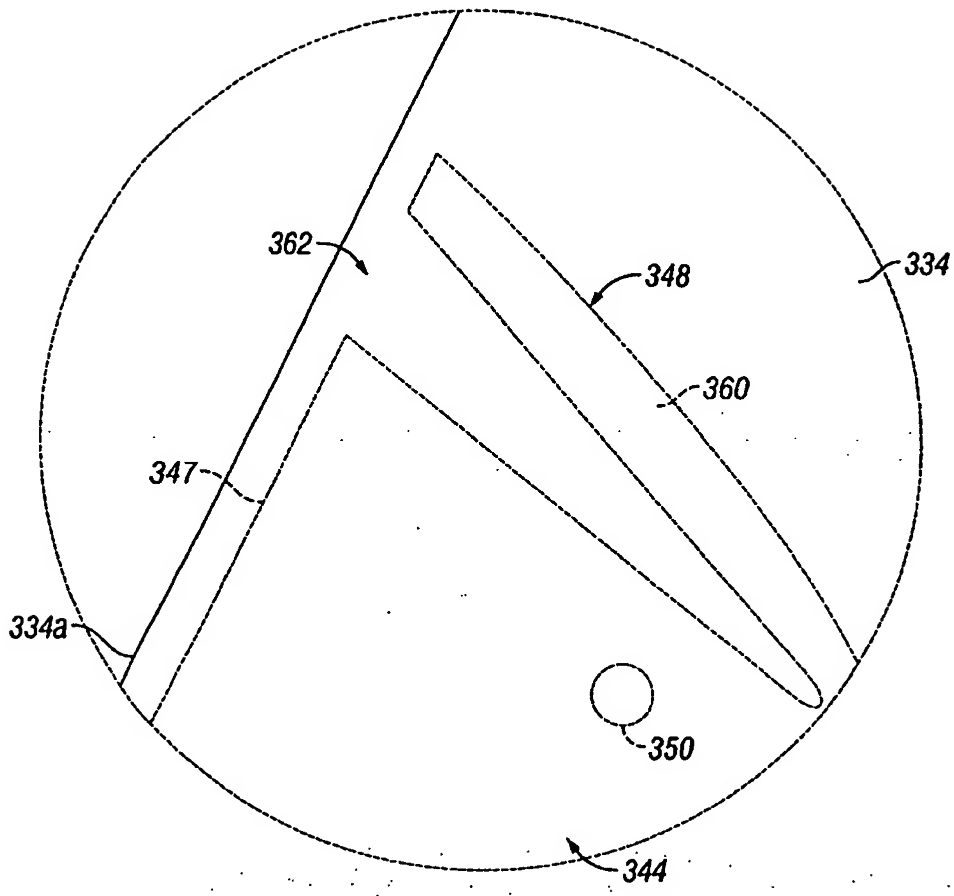

FIG. 3C

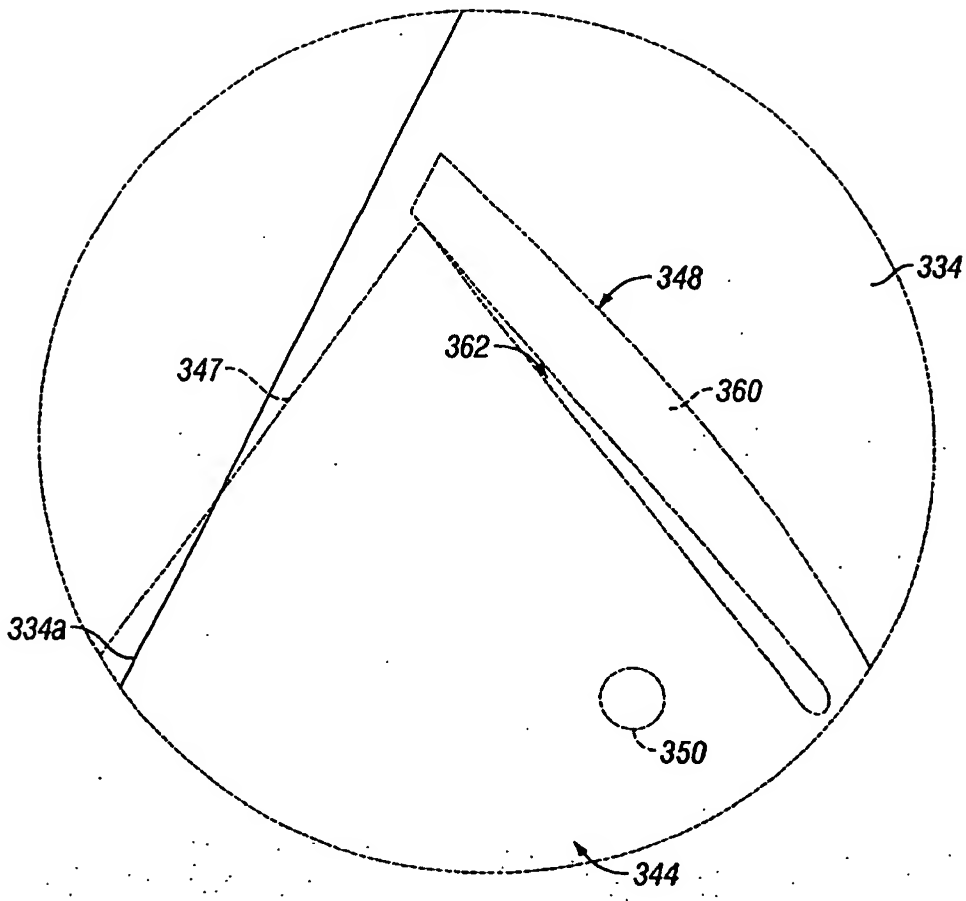

FIG. 3D

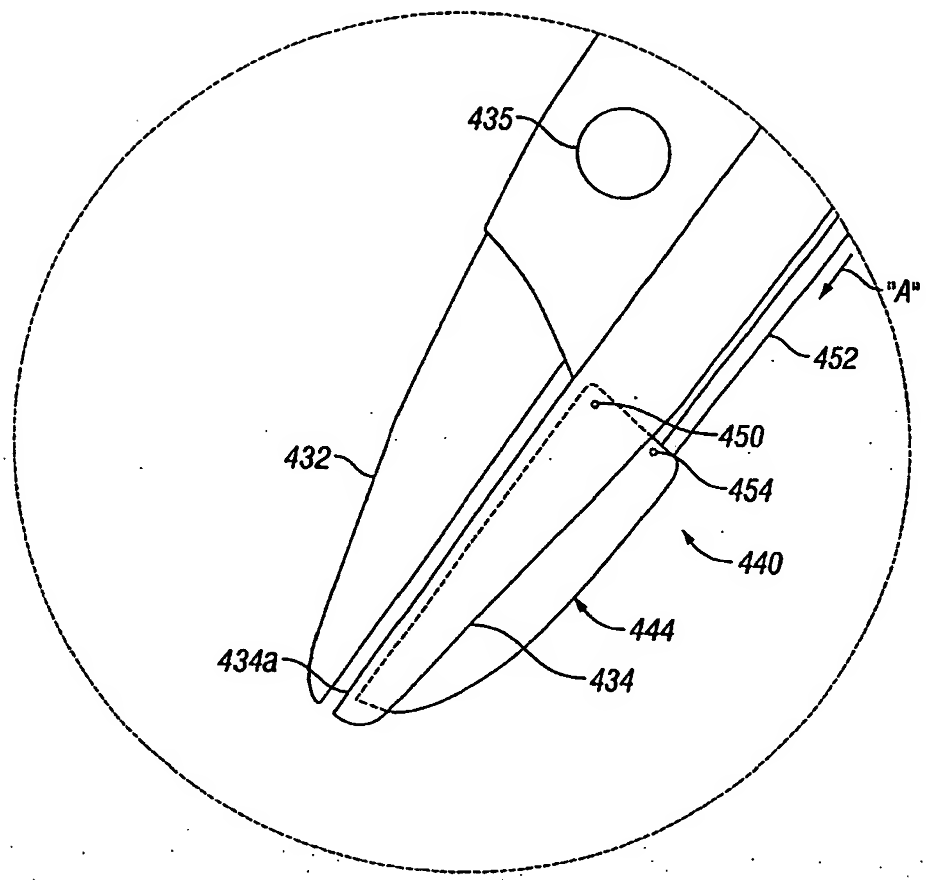

FIG. 4A

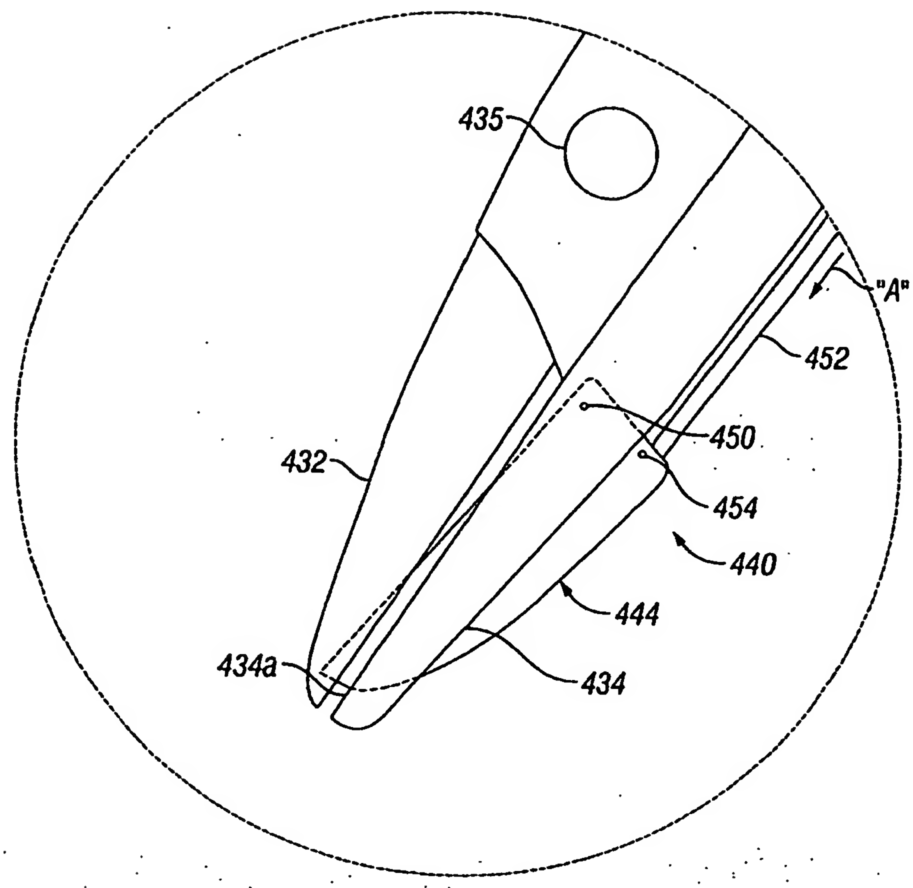

FIG. 4B

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Y	US 5 219 354 A (CHOUDHURY ET AL) 15 June 1993 (1993-06-15) * figure 4 * * figure 4A * * figure 9 * * figure 11 * * column 8, lines 25-68 * * column 9, lines 1,2 * ----- -/--	1,12-18	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 February 2006	Gentil, C

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Application Number
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The present search report has been drawn up for all claims

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